

Case Study 35

Variable speed drive on a boiler fan



VSD Unit (far right) improves efficiency of 40,000 lbs/h Boiler (centre right)

Case Study Objective

To demonstrate the energy savings which can be achieved by using a variable speed drive on the forced draught fan of a 40,000 lbs/h boiler

Potential Users

General boiler plant

Investment

Cost £7,100 (1989 prices)

Savings Achieved

190 MWh (684 GJ)/year worth £8,300/year (1989 prices)

Payback Period

11 months

Case Study Summary

An in house investigation was carried out by the Glasgow Royal Infirmary Works Department into the possible use of frequency inverters

for variable speed drives (VSD) in different applications throughout the Infirmary. The objective was to determine the potential for reducing energy consumption by this means and the survey highlighted many areas where VSD could be beneficial.

Because of its high utilisation, the 40,000 lbs/h (11.7 MW) steam boiler was selected for a pilot scheme, with a view to extending the principle to other items of plant should it prove to be cost effective.

The intention was to regulate the volume of air necessary for efficient combustion of the fuel by varying the speed of the burner forced draught (FD) fan motor. This method would replace the existing mechanical linkage and damper arrangement for air volume control.

The new equipment has operated well and has maintained good combustion conditions and high boiler efficiency. The actual savings achieved were greater than the original estimates.

Host Organisation

Greater Glasgow Health Board
Glasgow Royal Infirmary
Works Department
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Glasgow
G4 0SF

Equipment Supplier

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Honeywell House
Arlington Business Park
Bracknell
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Tel No: 01344 82600
Fax: 01344 826240
Mr M Morris

Monitoring Organisation

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Wellington House
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Oldham
OL8 2BA
Tel No: 0161 652 5331
Fax No: 0161 652 5336
Mr D W Lowther

There are other suppliers of similar energy efficient equipment in the market. Please consult your supply directories or contact ETSU who may be able to provide you with more details on request.



ENERGY EFFICIENCY

The Boiler Plant

The boiler plant at Glasgow Royal Infirmary serves the old and new sections of the hospital and comprises three steam boilers rated at 52,000 lbs/h, 40,000 lbs/h and 25,000 lbs/h from and at 100°C. Gas is the predominant fuel used with gas oil as standby.

The 40,000 lbs/h boiler generates approximately 90% of the steam consumed by the Infirmary each year. Only when there are excessive steam demands are the other boilers used. Steam demand by the Infirmary fluctuates in normal circumstances up to regular peak loads of approximately 30,000 lbs/h. The average annual steam load on the boiler in 1989 was 42%.

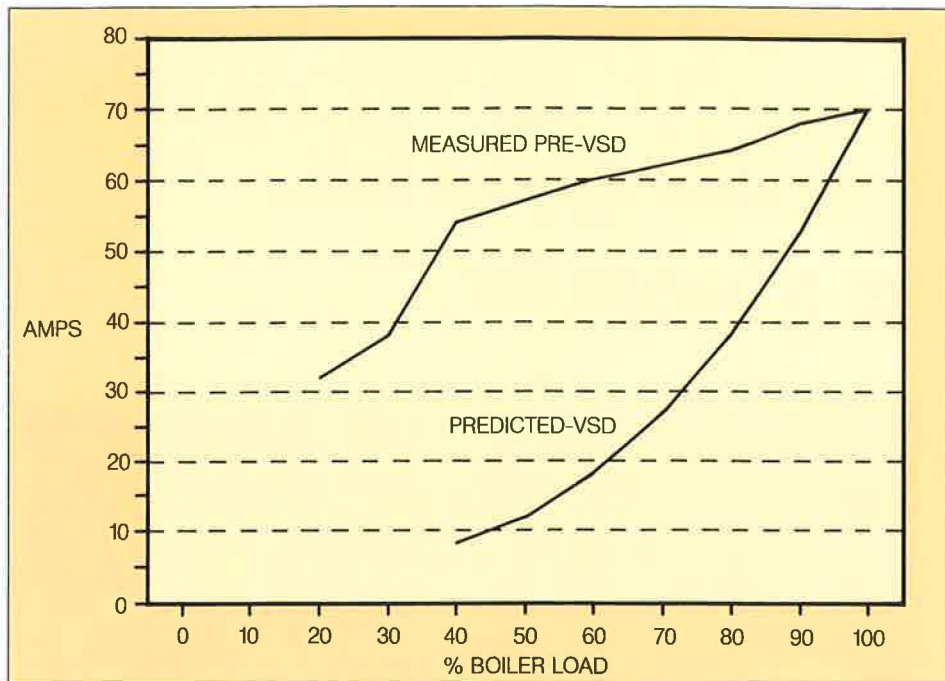
The boiler is fitted with a standard Saacke dual fuel burner with an integral forced draught fan. The existing fuel valve is controlled pneumatically, as were the original air damper actuators.

Preliminary Tests

Preliminary tests showed that the measured current taken by the 45 kW FD fan motor at maximum burner firing rate was 70 A. There was no significant reduction in the current until the burner modulated well down the firing range.

A comparison of these currents with those predicted for an inverter, indicated sufficient savings potential to encourage the Greater Glasgow Health Board to give financial backing to the project.

Due to the magnitude of the motor currents measured, an inverter rated at 37 kW was proposed.



FD Fan Motor Current

VSD Installation and Commissioning

Installation and commissioning of a Mitsubishi Freqrol Z 200 inverter was completed by Honeywell Control Systems in one day. Time was kept to a minimum by pre-assembling and wiring the inverter in a free standing control cabinet. The only additional component required on the burner was a signal converter. This transforms the pneumatic signal from the boiler pressure switch

to the fuel valve actuator, to a 0-10 V dc signal compatible with the inverter.

Honeywell was assisted during commissioning by a combustion engineer from NEI Cochran who ensured that optimum boiler efficiency was achieved by the new installation.

The procedure involved adjusting the FD fan speed at selected points across the burner firing range. The fuel valve cam profile was adjusted as necessary for efficient combustion and, as satisfactory conditions were reached, the motor speed was locked into the controller. This was repeated at 10% intervals until a permanent, characterised, FD fan speed curve was established over the full modulating range of the burner.

At the start of commissioning the FD fan air damper was locked in the fully open position. However, it became apparent that at fuel ignition and low fire stages, the flame was very unstable. The damper was therefore reinstated and adjusted to be closed fully at ignition and low firing rate to assist flame retention, moving to fully open immediately the firing rate started to increase. Since commissioning, neither the inverter nor the burner have required further adjustment.

Gas was used for firing the boiler throughout commissioning, this being the main fuel. As two types of fuel are available for use on the boiler, but only one speed curve can be programmed into the inverter, combustion conditions were also checked across the firing range with gas oil. This ensured that combustion remained at an acceptable efficiency with the motor settings if gas oil was used.

When installing the inverter, the original equipment was not removed or disconnected from the boiler or its associated plant. Therefore, in the event of failure of the inverter, the boiler could be restored to its previous operating regime with the minimum of delay.



Boiler Controls and VSD Unit

Energy Savings

The original energy saving estimates were based upon a comparison between the predicted motor current with VSD control and the measured values with damper control. This was made over a range of boiler steam loads.

In order to verify the savings, monitoring trials were conducted both before and after VSD installation. As a basis, the total steam generated was compared daily with the electricity consumption of the FD fan motor.

The pre-VSD trial, carried out over 28 days in October/November 1989, gave an average specific steam generation of 508 lbs/kWh. After installation of the inverter, a post-VSD trial over 27 days in February/March 1990 showed that this had improved to 1,616 lbs/kWh.

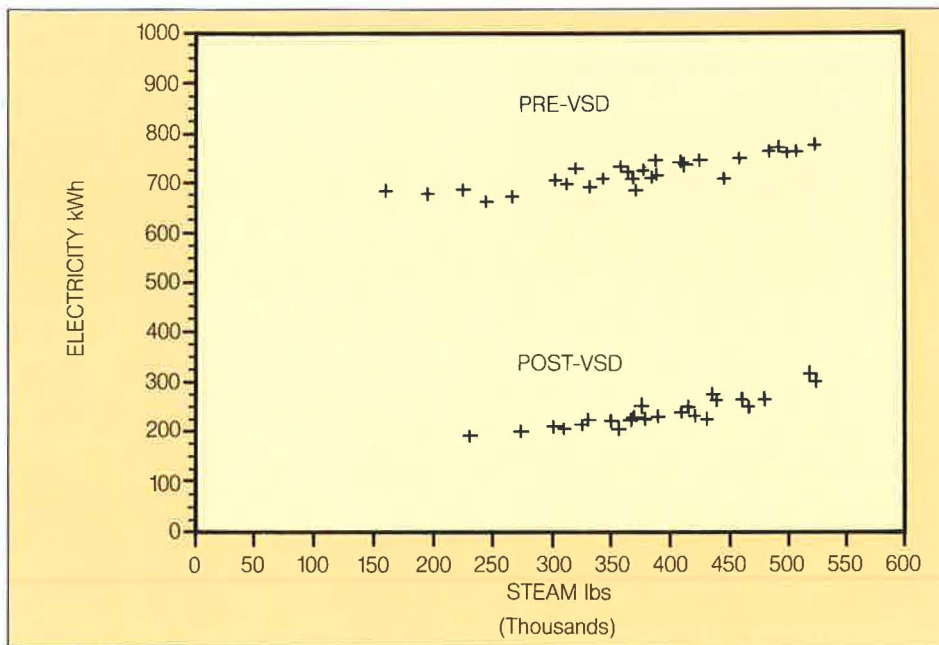
The overall boiler operating conditions were

almost identical in both monitoring periods, with average daily boiler loadings of just over 40%. The post-VSD steam generated was, at 10,467,900 lbs, only 1% higher than in the pre-VSD trial, but the electricity consumption fell from above 20,200 kWh to 6,500 kWh. This represented an energy saving of 68%.

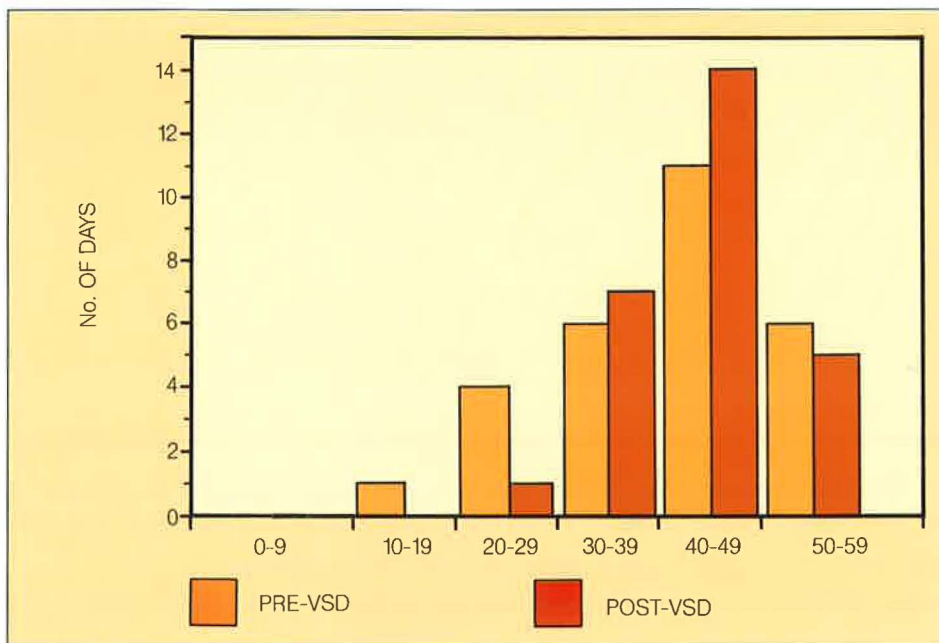
In addition to the energy saving, but not immediately quantifiable, are savings which are attributable to the repeatability of the motor speed once programmed into the inverter. This virtually nullifies any wear that takes place on the damper and actuator linkages. Such wear causes settings to wander and thus affects efficiency. Savings are therefore enhanced over time, because efficient combustion is maintained across the full modulating range of the burner during increasing and decreasing firing rates.



Frequency Inverter



Daily Steam Generated against Electricity Consumption



Boiler Load Frequency in Monitored Periods

Economic Analysis

The total steam generated in the boilerhouse is in excess of 156,000,000 lbs/year, of which approximately 90% is produced by the 40,000 lbs/h boiler. Based upon the specific steam generation figures obtained from the monitoring periods, the reduction in electricity consumption by the FD fan motor is estimated at 190,000 kWh/year or 684 GJ/year.

The boiler plant is operational at all times of the year and thus its electricity consumption forms a part of the base demand of the Infirmary. In considering financial savings, the higher cost components of the electricity tariff are therefore applicable.

Analysis of the monitored data showed that the average electrical demand of the motor was reduced by some 60%. Such a substantial decrease in maximum demand cannot be guaranteed over a long period of time, but with an allowance for this, the total savings achieved by use of the inverter are estimated at £8,300/year.

The total project cost for the VSD was £7,100, resulting in a simple payback period of 11 months.

Future Potential

The use of a frequency inverter for variable speed control of a boiler FD fan has shown to be cost effective, whilst maintaining good combustion conditions and high boiler efficiency.

The reliability of the inverter in keeping to the programmed motor speed profile during increasing and decreasing firing rates, has overcome the usual problems experienced with wear-induced changes in the damper and fuel valve settings.

Because gas is the main fuel and only one set of speeds can be programmed into the inverter, the same set points when using standby gas oil will be a compromise. This is acceptable for infrequent periods of interruption to the boiler gas supply. If, however, switching fuels is a regular practice, a system where two speed profiles can be stored should be considered.

Comments from Greater Glasgow Health Board

Detailed technical discussions between Glasgow Royal Infirmary Works Department and Honeywell Control Systems confirmed the use of VSD in reducing the considerable electrical demand of the Infirmary

The FD fan of the 40,000 lbs/h boiler was chosen for initial use of the equipment due to its operating principal of running a full speed fan against a partially closed damper for prolonged periods of time.

It was thought initially, and proved later, that substantial savings could be achieved by using VSD to reproduce the operating characteristics of the fixed speed fan and damper arrangement.

The installation has proved a total success with energy savings surpassing all expectations. Furthermore, reduced noise emission from the FD fan provides a more pleasant working environment within the boilerhouse.

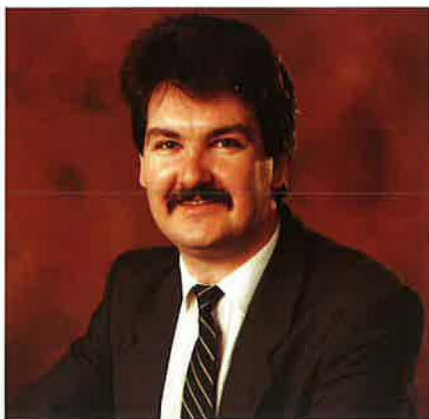
Other installations are planned for the near future, with the main one being the adaption of a 90 kW fixed speed, variable pitch centrifugal air fan to operate as a variable speed, fixed pitch unit.

The savings detailed in this case study more than justify the continued investment in VSD by the Greater Glasgow Health Board.



Glasgow Royal Infirmary (old section to rear and left)

Glasgow Royal Infirmary is a general hospital originally constructed in 1897. With a new section opened in 1982, it now houses 913 patients cared for by 3,500 staff. Situated on the East side of Glasgow, the complex covers an area of approximately 50,000m² and is one of 40 hospitals operated by the Greater Glasgow Health Board.



Iain McNally

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Glasgow Royal Infirmary

The installation described here was selected as an example of Good Practice, which is one element of The Department of the Environment's Best Practice programme, an Initiative aimed at advancing and promoting ways of improving the efficiency with which energy is used in the UK.

For further copies of this or other Best Practice programme publications please contact BRECSU and ETSU.

For buildings-related projects: Enquiries Bureau, BRECSU, Building Research Establishment, Garston, Watford, WD2 7JR. Tel 01923 664258. Fax 01923 664787.

For industrial projects: Energy Efficiency Enquiries Bureau, ETSU, Harwell, Didcot, Oxfordshire OX11 0RA. Tel No 01235 436747. Telex No 83135. Fax No 01235 433066.

Information on participation in the Best Practice programme and on energy efficiency generally is also available from your regional contact for Energy and Environmental Management.